P-8.1 Compare the strong and weak nuclear forces in terms of their roles in radioactivity.

Revised Taxonomy Levels 2.6 B Compare conceptual knowledge

In physical science students were introduced to the nucleus, protons, neutrons and radioactive isotopes.

It is essential for students to:

- Understand that the nucleus consists of protons and neutrons and that there is a large repulsive force between the protons.
- Understand that nuclei are stable because the short-range, strong (nuclear) force overcomes the repulsive electromagnetic force between protons.
  There are strong nuclear forces associated with:
  - Neutron-neutron interactions,
  - Proton-neutron interactions, and
  - Proton-proton interactions.
- Understand that the strong force is about the same for each type of interaction but the proton-proton interaction is partially mitigated by the repulsive electromagnetic force, so the net attractive force has a lower magnitude than in the other interactions.
- Understand that smaller nuclei are most stable when the number of protons is equal to the number of neutrons.
- Understand that larger nuclei are more stable when the number of neutrons is greater than the number of protons.
  - The addition of extra neutrons increases the total attractive force while not adding to the repulsive force.
  - When the atomic number is 83 or greater the repulsive forces between the protons cannot be compensated by additional neutrons.
  - Elements that contain more that 83 protons do not have stable nuclei.
- Understand that beta decay requires the introduction of an additional type of interaction called the weak force.
  - A beta decay results when a neutron transforms into a proton and a beta particle (or electron).

Teacher note: The Standard Model of particle physics describes the electromagnetic interaction and the weak interaction as two different aspects of a single electroweak interaction. The weak interaction changes one flavor of quark into another. The weak interaction is the only process in which a quark can change to another quark. In beta decay, a down quark in the neutron changes into an up quark by emitting a W boson, which then breaks up into a high-energy electron (beta particle) and an electron antineutrino leaving behind a proton.

Discussion of quark transmutation, W bosons, and antineutrinos are beyond the scope of this course.

Assessment
As the indicator states, the major focus of assessment is to compare (detect correspondences). Students should compare the effects of different forces and their roles in radioactivity.

Because the indicator is written as conceptual knowledge, assessments should require that students understand the "interrelationships among the basic elements within a larger structure that enable them to function together." In this case, assessments should show that students can compare the relationships between the forces in the nucleus and their roles in radioactivity.